Flowering incidences and breeding system in *Bambusa vulgaris*

*Bambusa vulgaris*, one of the most commonly cultivated bamboos (Poaceae), is known for its infrequent flowering and lack of seed set. Incidences of flowering have been reported from Bangladesh (in 1851, 1879, 1979, 1980–84), India (1890, 1996, 1997), Malaysia (1890s), Singapore (1892), Sri Lanka (1863, 1970s), Hawaii (1996), and China (1987). In addition, herbarium specimens housed in the Central National Herbarium, BSI, Calcutta have notes recording flowering from Indonesia (1890s, Kurz s.n.; 1921, Bakht of Brik 5549), Philippines (1908, C. B. Robinson 6213; 1911, A. D. E. Elmer 26068) and Cuba (1922, E. L. Ekman s.n.). Despite these 19 records of flowering over the past 150 years from 10 countries, there is not a single record of seed set in this species. This intriguing phenomenon is a matter of interest to botanists in general and bamboo specialists in particular, as flowering is followed by death of the plants. There is apprehension that this condition could even lead to a situation of the species becoming endangered or even getting extinct when all the individuals in all populations flower simultaneously. It is significant to note that all the recorded flowerings are either from islands or peninsulas (Figure 1).

The flowering clumps of *B. vulgaris* were kept under observation by the authors, since its flowering in May 1996 at Cherthala in Alappuzha district. This site (N9°40'453", E76°20'120") has sandy soil and numerous ditches and ponds. Of the total number of 39 clumps in the area, 37 had yellow stems with green stripes and two had pure green stems. Among these, 14 clumps, including the green ones flowered until May 1999, of which two dried up naturally and 11 were destroyed. One clump showed signs of survival even after flower initiation, i.e. reverting to vegetative stage. The occurrence of 14 flowering clumps could be the highest number reported from an area for this species.

There is a superstition that ‘flowering of bamboo heralds disaster’. This belief compelled the local people to burn them down, seriously hampering our work.

In March 2000, two clumps were seen in flower again in Kerala on the banks of river Pamba near the famous Maramon Convention site (N9°19'32"0", E76°41'25"8") in Kozhencherry, Pathanamthitta district. These clumps were in the initial stage of flowering as new healthy shoots were produced and spikelets were being developed from a few lower branches of old culms only (3 March 2000 K. C. Koshi & D. Harikumar 34300, TBGT).

The inflorescence is a large panicle reaching a maximum length of 130 cm, with heads of spikelets clustered around nodes of terminating leafy branches. Each head contains 2–44 spikelets. A young bud measuring 3–4 × 1 mm is cylindrical and has an acute apex. It takes 12 to 15 days for the bud to become a mature flattened spikelet of size 18–20 × 4–6 mm. The florets in a developing spikelet can be distinguished 7–9 days after its initiation. Mature spikelets consist of 6–9 florets and a rudimentary terminal one.

Opening of florets takes place in the morning hours between 6.30 and 10.30 am. Maximum number of florets was found opening during this period when the atmospheric temperature was 24 to 26°C, and relative humidity 80 to 87%. As explained earlier, during opening the tightly overlapping lemma and palea open out at the tip for 1.5 to 2 mm due to the pressure caused by the protrusion of the massive anthers and close back immediately after exertion of the stamens. It has been shown in rice that the turgid floral parts play an active role in the opening of florets, where lateral pressure on linear joints and leverage pressure at basal joints of flowering glumes are exerted by turgid filaments, stigma and turgid lodicules respectively. In *B. vulgaris*, the lemma and palea are not pushed wide apart possibly due to the malfunction of the lodicules and floret opening is mainly caused by the protrusion of anthers.

As observed in majority of flowers, the pistils are shorter than the palea. The short stature of the pistil coupled with the close overlapping of lemma and palea force the former to remain inside the floret, denying the chance for pollination. Very rarely in certain florets the pistil is observed to be longer than the palea. In such florets a small portion of stigmatic lobes, (ca. 1.5–2 mm) becomes exserted along with the stamens. The stigma is dry and no pollen grains are found on it. The simultaneous emergence of stamens and stigma
though rarely observed, indicates that there is no time gap between the male and female phases. Thus the florets are functionally 'males'.

Out of the 6–9 florets in a spikelet, generally 5–7 and rarely 8 florets open. Simultaneous opening of two or more florets in a single spikelet is also common. Depending upon the nature of opening of florets and the emergence of anthers the spikelets are grouped into five kinds in which the anthers emerge: (1) only from one basal floret at a time (Figure 2a) observed in 13.6%; (2) simultaneously from two florets (Figure 2b), 23.2%; (3) simultaneously from three florets (Figure 2c), 47.2%; (4) simultaneously from four florets (Figure 2d), 16%; (5) from second or third floret prior to the opening of basal florets, i.e. irregular type of opening (Figure 2e). Anthers from the rest of the florets, i.e. 5th (Figure 2f) and 6th (Figure 2g) emerge subsequently.

The anthers (5.5–6.0 × 0.5 mm) are bright pink or maroon. Bees visit the florets at the time of anther emergence and collect pollen grains (Figure 2h and i). They were trapped and identified. The common visitors are Trigona biroi Friese (Figure 2h) and Halictus sp. (Figure 2i). As pollination and fruit set are hitherto unknown in this species, understandably, the role of these bees is not clear.

The more frequent incidences of flowering in B. vulgaris in recent times pose a few questions. (1) Is flowering triggered by any climatic change? (2) Is this species heading towards gregarious flowering and eventual extinction? (3) Is this the reason for its doubtful occurrence in the wild? (4) Is the influence of sea one of the 'unknown circumstances to produce gametes'11 in this species? In any case conservation of genetic diversity of this species is very essential as it survives mainly in cultivation.
Scandium potential of some ixiolite-bearing pegmatites and tin slag of Bastar district, Madhya Pradesh, India

Scandium (Sc) is grouped along with rare earths because of its chemical similarities. It is a strategic element classified as a high-tech material by the US Department of Defence for special consideration in US policy making. Sc is used in high-intensity mercury vapour lamps, laser crystals and coatings, high-strength carbide, high-temperature superconductors, automobile catalysts, radioisotope tracer in refinery cracking and in nuclear reactor as neutron filter. In these applications there is no suitable substitute for Sc. The demand for Sc has grown in recent years due to an increase in laser research.

Sc is typically a dispersed element, which is evenly distributed in small quantities among various rocks and minerals. But it is found that minerals richest in Sc (0.001–0.03%) are those usually occurring in granites pegmatites. However, bulk of Sc present in the upper lithosphere is concentrated in the ferromagnesian minerals of ultrabasic and basic rocks such as pyroxene, gabbro, amphibolite, etc. Sc also occurs in the ferromagnesian minerals of silicic rocks. The part of Sc which has not substituted into the rock-forming minerals (pyroxene, amphibole, biotite, etc.) during the main stage of crystallization remains in the residual liquids and becomes enriched in pegmatites and pneumatolytic stages. Sc gets concentrated in minerals like garnet, tourmaline, biotite, muscovite, columbite, xenotime, zircon, wolframite, etc. Important Sc-bearing minerals include thortveitite (Sc$_2$Si$_2$O$_7$), strettite (ScPO$_4$•2H$_2$O), kolbectite (Sc, Be, Ca) (SiO$_4$, PO$_4$) and bazzite (scandium beryl). Thortveitite has been reported from pegmatites of Southern Norway and Madagascar. Strettite is reported from phosphate deposits of Utah, USA. Scandian ixiolite has also been reported from pegmatites of Madagascar. All these minerals are extremely rare. Economic concentration of Sc (<0.01 to 0.03%) is found in pegmatitic minerals and greisens which also, in fact, rarely occurs, the most abundant of them are tantaloniobates of rare earths, wolframite, cassiterite, beryl and zircon. However the Sc$_2$O$_3$ content of even these minerals reaches tenths of a per cent extremely rarely.

Sc, in different parts of the world, is occasionally recovered as a byproduct from wolframite, tin, zine, phosphate, zircon, tantalum wastes, phosphoric acid, clay, bauxite, etc. In these materials Sc, if present, is concentrated in trace amounts (<100 ppm) only. However, the US Bureau of Mines has identified a significant new source of Sc in an Oklolemo tantalum–niobium waste residue (0.24% Sc). In India, the possibility of recovering Sc from hafnium raffinates (Sc 30 ppm) was demonstrated.

The prices of Sc and its compounds are high, e.g. Sc metal prices for 1999: for powder metal, $270 per gram, sub-limed metal, $175 per gram; scandium bromide 99.99% purity; $91.80 per gram; scandium chloride 99.9% purity, $39.6 per gram; scandium iodide 99.999% purity, $151 per gram and scandium fluoride 99.9% purity, $80.1 per gram. Scandium oxide with 99.999% purity, $4000 per kilogram; scandium oxide 99.99% purity, $2100 per kilogram; scandium oxide 99.9% purity, $1400 per kilogram, and scandium oxide 99% purity, $900 per kilogram.

In view of the scarcity, and its high-tech applications, there is a need for locating resources of this rare metal. As indicated earlier, Sc is sometimes found to be associated with minerals of niobium–tantalum and tin. While studying various niobium–tantalum minerals from pegmatites around Metapal,